

5 **CLAIMS**

We claim:

1. A computerized method for dental imaging comprising:  
receiving a plurality of two-dimensional images of a oral cavity; and  
10 generating at least one three-dimensional image of the oral cavity from the  
plurality of two-dimensional images.
2. The computerized method of claim 1, wherein the plurality of two-dimensional  
images further comprises a plurality of two-dimensional optical images.
- 15 3. The computerized method of claim 1, further comprising:  
constructing a physical cast of the oral cavity from the three-dimensional image.
4. The computerized method of claim 1, further comprising:  
20 generating the plurality of two-dimensional images of the oral cavity from a  
common reference point in three-dimensional space.
5. The computerized method of claim 1, wherein the generating further comprises:  
generating shape-from-shading data from the plurality of two-dimensional images  
25 using a shape-from-shading process, the shape-from-shading data  
comprising a first plurality of three-dimensional points;  
generating range data comprising a second plurality of three-dimensional points  
from the plurality of two-dimensional images using a range-data process;  
fusing the range data to the shape-from-shading data, yielding fused data  
30 comprising a third plurality of three-dimensional points;  
registering the fused data, yielding registered data comprising a fourth plurality of  
three-dimensional points; and  
triangulating the registered data, yielding the at least one three-dimensional image  
of the oral cavity.

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- 5 6. The computerized method of claim 5, wherein the generating shape-from-shading data further comprises:
- estimating the direction of the illuminant from the plurality of two-dimensional images, in reference to camera intrinsic parameters; and
- 10 determining a solution to a brightness equation, yielding the shape-from-shading data comprising a first plurality of three-dimensional points.
7. The computerized method of claim 5, wherein the fusing the range data to the shape-from-shading data further comprises:
- 15 calculating the error difference in available depth measurements of the range data and the shape-from-shading data;
- approximating a surface the fits the error difference, yielding an approximated surface; and
- 20 correcting the shape-from-shading data from the approximated surface, yielding fused data comprising a third plurality of three-dimensional points;
8. A computer-readable medium having computer-executable instructions to cause a computer to perform a method comprising:
- receiving a plurality of two-dimensional optical images of an oral cavity; and
- 25 generating at least one three-dimensional image of the oral cavity from the plurality of two-dimensional images.
9. The computerized method of claim 8, further comprising:
- constructing a physical cast of the oral cavity from the three-dimensional image.
- 30 10. The computerized method of claim 8, further comprising:
- generating the plurality of two-dimensional images of the oral cavity from a common reference point in three-dimensional space.
11. The computerized method of claim 8, wherein the generating further comprises:

5 generating shape-from-shading data from the plurality of two-dimensional images  
using a shape-from-shading process, the shape-from-shading data  
comprising a first plurality of three-dimensional points;  
generating range data comprising a second plurality of three-dimensional points  
from the plurality of two-dimensional images using a range-data process;  
10 fusing the range data to the shape-from-shading data, yielding fused data  
comprising a third plurality of three-dimensional points;  
registering the fused data, yielding registered data comprising a fourth plurality of  
three-dimensional points; and  
triangulating the registered data, yielding the at least one three-dimensional image  
15 of the oral cavity.

12. The computerized method of claim 11, wherein the generating shape-from-  
shading data further comprises:

20 estimating the direction of the illuminant from the plurality of two-dimensional  
images, in reference to camera intrinsic parameters; and  
determining a solution to a brightness equation, yielding the shape-from-shading  
data comprising a first plurality of three-dimensional points.

13. The computerized method of claim 11, wherein the fusing the range data to the  
25 shape-from-shading data further comprises:

calculating the error difference in available depth measurements of the range data  
and the shape-from-shading data;  
approximating a surface the fits the error difference, yielding an approximated  
surface; and  
30 correcting the shape-from-shading data from the approximated surface, yielding  
fused data comprising a third plurality of three-dimensional points;

14. A three-dimensional digital image of a human oral cavity produced by the process  
comprising:

5 generating a plurality of two-dimensional optical images of the oral cavity from a  
common reference point in three-dimensional space;  
generating shape-from-shading data from the plurality of two-dimensional images  
using a shape-from-shading process, the shape-from-shading data  
comprising a first plurality of three-dimensional points;  
10 generating range data comprising a second plurality of three-dimensional points  
from the plurality of two-dimensional images using a range-data process;  
fusing the range data to the shape-from-shading data, yielding fused data  
comprising a third plurality of three-dimensional points;  
registering the fused data, yielding registered data comprising a fourth plurality of  
15 three-dimensional points; and  
triangulating the registered data, yielding the one three-dimensional image of the  
oral cavity.

15. The three-dimensional digital image of a human oral cavity of claim 14, produced  
20 by the process wherein generating shape-from-shading data further comprises:  
estimating the direction of the illuminant from the plurality of two-dimensional  
images, in reference to camera intrinsic parameters.

16. A system for dental diagnosis comprising:  
25 a processor; and  
software means operative on the processor for generating a three-dimensional  
image of a human jaw, including generating shape-from-shading data that  
is generated from a direction of an illuminant of the jaw that is estimated  
in reference to camera intrinsic parameters.

17. A computerized system comprising:  
30 a digitizer providing five degrees of freedom, having an arm;  
a charge coupled device camera, rigidly mounted on the arm of the digitizer; and  
a computer, operably coupled to the digitizer and the camera; receiving coordinate  
35 measurements from the digitizer and a plurality of two-dimensional

5 images from the camera; and generating a digital three-dimensional model  
from the coordinate measurements and from the plurality of two-  
dimensional images.

18. The computerized system of claim 17, further comprising:  
10 a rapid prototyping machine operably coupled to the computer, receiving the  
digital three-dimensional model and generating a physical model of the  
digital three-dimensional model.

19. The computerized system of claim 17, further comprising:  
15 a display operably coupled to the computer, receiving the digital three-  
dimensional model and generating an image of the digital three-  
dimensional model.

20. The computerized system of claim 17, the computer further comprises:  
20 a computer readable medium comprising means of:  
generating shape-from-shading data from the plurality of two-dimensional images  
using a shape-from-shading process, the shape-from-shading data  
comprising a first plurality of three-dimensional points;  
generating range data comprising a second plurality of three-dimensional points  
25 from the plurality of two-dimensional images using a range-data process;  
fusing the range data to the shape-from-shading data, yielding fused data  
comprising a third plurality of three-dimensional points;  
registering the fused data, yielding registered data comprising a fourth plurality of  
three-dimensional points; and  
30 triangulating the registered data, yielding the one three-dimensional image of the  
oral cavity.